## REMARKS

In view of the above amendments and the following remarks, reconsideration of the rejections contained in the Office Action of August 18, 2004 is respectfully requested.

In order to make necessary editorial corrections, the entire specification and abstract have been reviewed and revised. As the revisions are quite extensive, the amendments to the specification and abstract have been incorporated into the attached substitute specification and abstract. For the Examiner's benefit, a marked-up copy of the specification indicating the changes made thereto is also enclosed. No new matter has been added by the revisions. Entry of the substitute specification is thus respectfully requested.

The Examiner rejected claims 8 and 12 under 35 USC § 112, second paragraph, as being indefinite. In particular, the Examiner asserted that the claims contain several phrases which render the scope of the claims vague and indefinite. In order to address these formal rejections, and in order to place the original claims in a proper form according to U.S. practice, the original claims have been cancelled and replaced with new claims 14-27, and the new claims have been drafted so as to fully comply with all the requirements of 35 USC § 112. Therefore, it is respectfully submitted that the Examiner's formal rejections under § 112 are not applicable to the new claims.

On pages 2-6 of the Office Action, the Examiner rejected original claims 1-13 in view of the prior art. In particular, the Examiner rejected original independent claim 1 as being unpatentable over the Yamamoto reference (USP 6,032,630) in view of the Nakajima reference (USP 5,389,452). In addition, the Examiner rejected dependent claims 2-13 in view of the Yamamoto reference and the Nakajima reference, and further in view of the Anno reference (USP 5,204,890), the JP'938 reference (Japanese Publication 8129938A), the Christini reference (USP 3,936,577), or the Lust reference (USP 6,592,356). However, as indicated above, original claims 1-13 have been cancelled and replaced with new claims 14-27. For the reasons discussed below, it is respectfully submitted that the new claims are clearly patentable over the prior art of record.

The present invention is directed to a lash adjuster which, as explained in paragraph [0001] is designed to automatically adjust a valve clearance in an internal combustion engine. As recited in new independent claim 14, the lash adjuster of the present invention includes a lifter body to be

axially slidably mounted in a valve opening-and-closing transmission path to transmit force from a cam to a valve though a valve stem, a nut member on the lifter body, an adjuster screw shaped and arranged axially while rotating within the nut member so as to automatically adjust a valve clearance, and an elastic member for axially biasing the adjuster screw.

As explained in paragraph [0005] of the original specification, a lash adjuster with the general arrangement as described above will automatically adjust the valve clearance because the elastic member exerts a pressure on the adjuster screw so that the adjuster screw will move axially while rotating within the nut member. As a result of the friction forces between the threads of the adjuster screw and the nut member, as well as the opposing forces applied to the adjuster screw, including the force of the elastic member, the adjuster screw of the lash adjuster will be properly balanced so as to provide smooth operation.

As further explained in the specification, motor oil including organic molybdenum("FM oil") is used extensively today in order to reduce friction within the internal combustion engine, thereby improving the performance of the engine (see paragraph [0009] of the original specification). However, as noted in paragraph [0011] of the original specification, the FM oil can negatively affect the performance of the lash adjuster. In particular, the FM oil will tend to reduce the friction coefficient between the thread surface of the nut member and the thread surface of the adjuster screw to a level at which slip occurs. In other words, the FM oil will produce a reduced friction coefficient which will cause the adjuster screw to inadvertently move in an axial direction, thereby causing abnormal sounds during engine operation, and possibly damage.

Thus, as explained in paragraph [0012] of the original specification, the present invention has been developed in order to address the problems caused in lash adjusters when motor oil containing organic molybdenum (FM oil) is used. In this regard, the present inventors have determined: (1) that in order to prevent the friction coefficient between two metallic members from dropping below an acceptable level, the formation of a tribochemical film between the metallic members must be sufficiently suppressed; and (2) in the presence of oil containing organic molybdenum (FM oil), the formation of such a tribochemical film between two metallic members

can be sufficiently suppressed by forming at least one of the two metallic members from a material that does not react with oil additives of the oil containing organic molybdenum.

Thus, as further recited in new independent claim 14, the inventors have developed a lash adjuster in which a pressure-side thread surface of one or both of the adjuster screw and the nut member is formed of *a material that will not react with oil additives of oil containing organic molybdenum.* As explained in paragraph [0036] of the original specification, the formation of a tribochemical reactive layer between the thread surfaces will therefore be sufficiently suppressed, so that the friction coefficient between the threads of the nut member and the adjuster screw will not decrease below an acceptable level. As such, the adjuster screw will not unintentionally slip within the nut member, and the performance of the lash adjuster will be maintained - even if a motor oil containing organic molybdenum is used.

The Yamamoto reference discloses a valve lifter including an adjuster screw 13 threaded into nut member 11, and capable of moving in an axial direction due to a biasing pressure from the elastic member 15. However, the Examiner noted that the Yamamoto reference does not disclose or even suggest that any portion of the adjuster screw or nut member is made of a material that will not react with oil additives of oil containing organic molybdenum.

Nonetheless, the Examiner asserted that the Nakajima reference teaches "that it is conventional in the art of aluminum alloy, to utilize the aluminum alloy, a nonferrous metal, coated with a lubricant containing organic molybdenum." The Examiner further asserted that it would therefore be obvious to one of ordinary skill in the art to have utilized the aluminum alloy taught by the Nakajima reference to make the screw and nut in the Yamamoto reference because "the use thereof would provide a better friction and wear resistance valve lash adjuster." However, the Applicants submit that one of ordinary skill in the art would not be motivated to combine the Nakajima reference with the Yamamoto reference in the manner suggested by the Examiner for several reasons, as explained below.

Firstly, because the Nakajima reference teaches away from the present invention, one of ordinary skill would not be motivated by the Nakajima reference to modify the Yamamoto reference to obtain the present invention. In particular, as explained in column 1, lines 30-43 of the Nakajima

reference, one primary object of the Nakajima reference is to address the problem of "*insufficient* lubricity" in aluminum plates. In other words, a primary object of the Nakajima reference is to further *reduce* friction. In direct contrast to this object, the present invention as explained above is directed to a lash adjuster in which a pressure-side thread surface of the adjuster screw and/or the nut member is formed of a material that will not react with oil additives of oil containing organic molybdenum. As such, the friction coefficient between the threads of the nut member and the adjuster screw will not decrease below a minimally sufficient level so as to avoid slippage. Thus, because the Nakajima reference essentially teaches the desirability of *decreasing* friction, while the present invention is directed to an arrangement that will *at least maintain a minimal amount of friction*, it is submitted that the Nakajima reference actually *teaches away* from the present invention.

Secondly, it is submitted that the Nakajima reference cannot be combined with the Yamamoto reference because the Nakajiima reference is from a different field of art. In this regard, it is well established that in order for an Examiner to rely on a reference in an obviousness rejection, the reference must be analogous prior art. In particular, "the reference must either be in the field of Applicants' endeavor or, if not, be reasonably pertinent to the particular problem with which the inventor was concerned." See *In re Oetiker*, 977 F.2d 1443, 1446, 24 USPQ 2d 1443, 1445 (Fed. Cir. 1992). In this regard, as explained above, the present invention is directed to a lash adjuster for adjusting a valve clearance in an internal combustion engine. The Nakajima reference, however, is directed to an aluminum plate that has excellent formability. Thus, the Nakajima reference is <u>not</u> in the field of the Applicants' endeavor. Furthermore, the Nakajima reference is <u>not</u> reasonably pertinent to the particular problem with which the inventor was concerned. In this regard, a reference is considered to be reasonably pertinent "if, even though it may be in a different field from that of the inventor's endeavor, it is one which, because of the matter with which it deals, logically would have commended itself to an inventor's attention in considering his problem." See *State Contracting and Engineering Corporation v. Condotte America, Inc.*, 346F.3d 1057, 1069, 68 USPQ 2d 1481, 1490 (Fed. Cir. 2003). As noted above, the Nakajima reference is directed to an aluminum plate which has excellent formability, and which has sufficient lubricity. In this regard, because the Nakajima reference has an object of improving lubrication (i.e., *reducing* a coefficient of friction),

the teachings of the Nakajima reference would <u>not</u> have commended itself to an inventor's attention in considering the problem of maintaining or increasing a friction coefficient between a nut member and an adjuster screw in conventional lash adjusters. Moreover, because the aluminum plate of the Nakajima reference is significantly different in shape, intended use, and many other respects from the nut member and the adjuster screw of the present invention, the concerns regarding decreasing friction coefficients in conventional lash adjusters (or any other components) are not even raised in the Nakajima reference. Therefore, without the discussion or even suggestion of these problems, and in view of the contrary teachings of the Nakajima reference, it is submitted that the Nakajima reference would not have commended itself to one of ordinary skill in the art in order to address the problems overcome by the present invention as recited in new independent claim 14.

As explained above, one of ordinary skill in the art would not be motivated to combine the Nakajima reference and the Yamamoto reference in the manner suggested by the Examiner so as to obtain the invention recited in new independent claim 14. Moreover, the Anno reference, the JP'938 reference, the Christini reference, and the Lust reference also <u>do not</u> provide the motivation to one of ordinary skill in the art to modify the Yamamoto reference in the manner suggested by the Examiner. Accordingly, it is respectfully submitted that new independent claim 14 and the claims that depend therefrom are clearly patentable over the prior art of record.

In view of the above amendments and remarks, it is submitted that the present application is now in condition for allowance. However, if the Examiner should have any comments or suggestions to help speed the prosecution of this application, the Examiner is requested to contact the Applicant's undersigned representative.

Respectfully submitted,

Yoshiteru YASUDA et al.

By: ______________________

W. Douglas Hahm
Registration No. 44,142
Attorney for Applicants

WDH/gtg
Washington, D.C. 20006-1021
Telephone (202) 721-8200
Facsimile (202) 721-8250
December 20, 2004

# LASH ADJUSTER FOR VALVE GEAR

## BACKGROUND OF THE INVENTION

**[0001]** This invention relates to a lash adjuster for automatically adjusting the valve clearance of a valve gear in an internal combustion engine.

**[0002]** In a line for feeding fuel to an internal combustion engine or a line for discharging exhaust gas, a valve gear is provided to open and close an intake valve or exhaust valve (hereinafter called simply valve) by the rotation of a cam. This valve gear includes a lash adjuster for automatically adjusting the valve clearance.

**[0003]** Such a valve gear includes a cam, a valve and a valve stem provided on the valve. When the end face of the valve stem is pressed against the end face of an adjuster screw by the force of a valve spring which presses the valve stem toward the cam, this force is transmitted to the cam through a lifter body to open and close the valve as the cam rotates. Generally, the lash adjuster is mounted between the cam and the valve stem provided on the valve.

**[0004]** Such lash adjusters are known in which a threaded hole having a closed end is formed in the lifter body, the adjuster screw in threaded engagement with the threaded hole is axially biased by an elastic member mounted in the threaded hole at its closed end, and the

female threads of the threaded hole and the male threads of the adjuster screw are serration-shaped such that the flank angle of the pressure flanks, which receive the push-in load applied to the adjuster screw, is greater than the flank angle of the clearance flanks to adjust any valve clearance. Such adjusters are disclosed in US patent 4548168, and JP patent publications 11-324617 and 11-324618.

**[0005]** In such a lash adjuster, when a valve clearance tends to develop between the valve stem and the adjuster screw ~~due e.g.~~ due, for example, to thermal expansion of the cylinder head, the adjuster screw moves axially while rotating along the clearance flanks under the push-in force of the elastic member, thereby absorbing the valve clearance. Conversely, when the adjuster screw is acted upon by a push-in force from the valve stem, it retracts until an axial gap formed at the thread engagement portions between the male and female threads disappears. When further push-in force is applied, it is borne by the pressure flanks, which are pressed against each other, thereby preventing the adjuster screw from retracting while rotating.

**[0006]** If the distance between the valve stem end and the camshaft shortens ~~due e.g.~~ due, for example, to wear of the valve seat, the adjuster screw prevents the valve from being gradually pushed in due to axial variable loads

applied from the camshaft, so that a pressure leak occurs because the valve is not completely shut even when the base circle of the cam abuts the cylinder head. At this time, the adjuster screw is further pushed in by an amount corresponding to the play of the threads from a position where the minimum value of the axial variable loads is zero, but never retracts any further.

**[0007]** Serration-shaped threads used for such a lash adjuster have two kinds of flanks, i.e. pressure flanks, which receive push-in loads applied to the adjuster screw, and clearance flanks, and have self-sustainable friction coefficients $\mu s$ determined univocally by the friction coefficients $\mu$ between the thread surfaces of the male threads and female threads on the respective flank surfaces, and thread specifications. Generally, ~~it is~~ the threads are designed such that the self-sustainable friction coefficient $\mu s$ of the pressure flanks is smaller than the friction coefficient $\mu$ between the thread surfaces, and that the self-sustainable friction coefficient $\mu s$ of the clearance flanks is greater than the friction coefficient $\mu$ between the thread surfaces.

**[0008]** Specifically, the friction coefficient $\mu$ between the thread surfaces in such a lash adjuster is experimentally known to be about 0.1-0.15. For example, in the embodiments of the inventions described in the above-mentioned three patent publications, by setting the

lead angle $\alpha$ = 11.5°, pressure flank angle $\theta_1$ = 75°, clearance flank angle $\theta_2$ = 15°, ~~it~~ the threads can be designed such that the self-sustainable friction coefficient $\mu s$ of the pressure flanks is smaller than the friction coefficient $\mu$ between the thread surfaces, and the self-sustainable friction coefficient $\mu s$ of the clearance flanks is greater than the friction coefficient $\mu$ between the thread surfaces (see Fig. 8).

**[0009]** On the other hand, in recent years, in automotive engines, for the purpose of reducing friction and direct contact of slide portions, motor oil containing organic molybdenum (friction modifier oil; hereinafter referred to as FM oil) ~~are~~ is generally used. By using FM oil, a film that ~~is~~ has an extremely low ~~in~~ friction coefficient is formed on slide portions, so that slide resistance of various portions decreases. This helps to improve the fuel cost of automobiles. Typical organic molybdenums include molybdenum dialkyldithiocarbamate sulfide (alias molybdenum dithiocarbamate; MoDTC), and oxymolybdenum sulfide · dialkyldithiophosphate (alias molybdenum dithiophosphate; MoDTP). They have friction relaxing property, wear resistance, extreme pressure property, and oxidation resistance.

**[0010]** These effects are achieved in cooperation with ZnDTP (zinc dialkyldithiophosphate) which is an oil additive, and it is known that the friction coefficient can be

reduced more markedly than if used alone. It is said that this is because ZnDTP forms iron phosphate on the substrate, and forms an $MoS_2$ film thereon. Also, ZnDTP is high in reactivity with iron, and it is reported that such a tribochemical reactive film is not formed on slide surfaces provided ~~with e.g.~~ with, for example, DLC film due to its chemical stability (technical magazine "TRIBOLOGIST" Vol. 47/No. 11/2002/page 819).

**[0011]** But in an engine in which is mounted such a lash adjuster, if FM oil described above is used, the friction coefficient $\mu$ between the thread surfaces may drop extremely to about 0.04. If the friction coefficient $\mu$ falls below the self-sustainable friction coefficient $\mu s$ of the pressure flanks, slip may occur on the pressure flanks. If slip on the pressure flanks is excessive, when axial load is applied to the lash adjuster, the adjuster screw is pushed in, thus causing valve lift loss and causing the valve to get impulsively seated, thus producing abnormal sounds.

**[0012]** An object of this invention is to provide an improved lash adjuster for a valve gear employing ~~the~~ a serration-shaped thread mechanism which suppresses the formation of tribochemical reactive film by using ~~such~~ materials ~~as the materials~~ for the adjuster screw and the nut ~~member~~ member, or ~~the materials~~ for the thread surfaces ~~thereof that~~ thereof, with which the friction coefficient between the thread surfaces will not extremely ~~fall~~ decrease

even under conditions in which FM oil is used for the engine.

## SUMMARY OF THE INVENTION

**[0013]** According to this invention, there is provided a lash adjuster in a valve gear comprising a nut member provided on a lifter body axially slidably mounted in a transmission path for a valve opening/closing force transmitted from a cam to a valve through a valve stem, an adjuster screw moving axially by rotating in the nut member for automatically adjusting a valve clearance, and an elastic member for axially biasing the adjuster ~~screw, wherein female~~ screw. Female threads of the nut member and male threads formed on the outer periphery of the adjuster screw are serration-shaped such that the flank angle of pressure flanks acted on by axial push-in force applied to the adjuster screw is greater than the flank angle of clearance ~~flanks, and wherein one~~ flanks. One or both of the adjuster screw and the nut member, or pressure side thread surfaces of one or both of ~~them~~ them, are formed of a material that will not react with oil additives of oil containing organic molybdenum.

**[0014]** With this lash adjuster, the formation of a tribochemical reactive film is suppressed under conditions in which FM oil is used. The prerequisite thereof is that the

nut member and the adjuster screw used have serration-shaped threads.

[0015] Serration-shaped threads used for the lash adjuster will now be described. Generally, if axial compressive loads are applied to threads, irrespective of the magnitude of the axial loads, if the friction coefficient $\mu$ between the thread surfaces is greater than the self-sustainable friction coefficient $\mu s = \tan\alpha \cos\theta$ ($\alpha$: lead angle, $\theta$: flank angle), which is determined univocally by the specs of the threads, the threads will stand still without causing slip rotation. Conversely, if the friction coefficient $\mu$ between the thread surfaces is smaller than the self-sustainable friction coefficients $\mu s$, the threads will rotate while slipping and be pushed in.

[0016] With the serration-shaped threads used for the lash adjuster, the flank angle of the pressure flank, which receives the push-in load applied to the adjuster screw, is larger than the flank angle of the clearance flank. Their flank angles are designed such that the self-sustainable friction coefficient $\mu s$ of the pressure flank surfaces is smaller than the friction coefficient $\mu$ between the thread surfaces, and the self-sustainable friction coefficient $\mu s$ of the clearance flank surfaces is larger than the friction coefficient $\mu$ between the thread surfaces.

[0017] As a result, in mounting the lash adjuster in an internal combustion engine, if valve clearance tends to

develop between the valve stem and the adjuster screw ~~due e.g.~~ due, for example, to thermal expansion of the cylinder head, the adjuster screw will move axially while turning along the clearance flanks under the biasing force of the elastic member, thus absorbing the valve clearance.

**[0018]** When the adjuster screw is acted on by a push-in force from the valve stem, it will retract until the axial thread gap formed between the male and female threads disappears. When further push-in force acts, it is borne by the pressure flanks, which are pressed against each other, thereby preventing the adjuster screw from retracting while rotating.

**[0019]** With the lash adjuster using such serration-shaped threads, since a material that will not react with oil additives of FM oil is used for the materials of one or both of the nut member and the adjuster screw or the pressure side thread surfaces of one or both of them, the formation of a film such as $MoS_2$ film, which is a tribochemical reactive film, is suppressed. This prevents the friction coefficient $\mu$ between the thread surfaces from reducing extremely. Thus stable valve action is assured.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0020]** Other features and objects of the present invention will become apparent from the following

description made with reference to the accompanying drawings, in which:

Fig. 1 is a vertical sectional front view of a valve gear using a lash adjuster embodying this invention;

Fig. 2 is an enlarged sectional view of the lash adjuster;

Fig. 3 is an enlarged plan view of the lash adjuster;

Fig. 4 is a graph showing measurement results for the valve lift of the lash adjuster with FM oil used (adjuster screw and nut member formed with TiN layer);

Fig. 5 is a similar graph with FM oil used (adjuster screw formed with DLC ceramic film);

Fig. 6 is a similar graph with FM oil used (nut member: plating treatment);

Fig. 7 is a graph showing measurement results for the valve lift of a prior art lash adjuster with FM oil used (adjuster screw and nut member made of carburizing steel subjected to carburizing); and

Fig. 8 is a graph showing relationship between thread specs and self-sustainable friction coefficient.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

**[0021]** An embodiment of this invention will now be described with reference to the drawings. Fig. 1 shows an

example of a valve gear for opening and closing an intake port. The valve gear has a valve 5 for opening and closing an intake port formed in a cylinder head B. The valve 5 has a valve stem 2 which is axially slidably supported by a stem guide 2a mounted on the cylinder head B.

**[0022]** Between the valve stem 2 and a cam 1 provided thereover, a lash adjuster A is mounted. The lash adjuster A is slidable along a guide hole 7 formed in the cylinder head B. As shown in Fig. 2, the lash adjuster A has a cylindrical lifter body 11 having its top closed. A protrusion is provided on the inner surface of an end plate 12 of the lifter body 11. The protrusion comprises a nut member 13. A flange 13a provided at the end of the nut member 13 is fixed to the inner surface of the end plate 12.

**[0023]** An adjuster screw 15 is in threaded engagement with a threaded hole 14 of the nut member 13 in which are formed double threads. A return spring 16 is mounted between the bottom of a recess formed in the top end face of the adjuster screw 15 and the inner surface of the end plate 12. The materials of the nut member ~~13~~13, and the adjuster screw ~~15~~15, and the material of their threaded ~~surface~~ surfaces are described later.

**[0024]** As shown in Fig. 1, at an upper portion of the valve stem 2, a valve retainer 3 is mounted. The valve retainer 3 is biased upwardly by a valve spring 4 mounted thereunder. Under its biasing force, the top end of the

valve stem 2 is pressed against the bottom end of the adjuster screw 15, so that the top surface of the end plate 12 of the lash adjuster A is pressed against the cam 1.

**[0025]** As shown in Fig. 2, the threads of the adjuster screw 15 and the threaded hole 14, with which the adjuster screw 15 is in threaded engagement, are serration-shaped so that the flank angle of pressure flanks 17, which receive an axial push-in force applied to the adjuster screw 15 from the valve stem 2, is greater than the flank angle of clearance flanks 18. The relation between the flank angles and lead angles of the serration-shaped threads is such that the adjuster screw 15 is adapted to move downwardly while rotating under the elastic force of the return spring 16.

**[0026]** When the adjuster screw 15 is acted upon by a push-in force from the valve stem 2, the push-in force will be borne by the pressure flanks 17. ~~Thus~~ Thus, the adjuster screw 15 hardly turns though it tends to be pushed in by vibration of the cam 1. It will move upwardly while rotating to a position where the force of the valve spring 4 balances with that of the return spring 16.

**[0027]** The return spring 16 comprises a cylindrical coil spring. An end coil portion 16a at one end thereof has a smaller diameter than the coil portion between the end coil portions at both ends. This return spring 16 is mounted such that the small-diameter end coil portion 16a touches

the inner surface of the end plate 12 of the lifter body 11. The return spring 16 may be mounted such that the small-diameter end coil portion 16a is in contact with the adjuster screw 15.

**[0028]** As shown in Fig. 2, at an upper portion of the inner periphery of the lifter body 11, an engaging groove 19 and a tapered surface 20 located thereunder are provided. An elastic ring 21 is mounted in the engaging groove 19. As shown in Fig. 3, the elastic ring 21 comprises a disk spring having one portion in its circumference cut off so as to be elastically deformable in diametric and axial directions. By the axial elastic force, ~~it~~ the ring 21 presses the flange 13a at the outer periphery of the nut member 13 against the inner surface of the end plate 12 of the lifter body 11 to prevent the nut member 13 from turning relative to the lifter body 11.

**[0029]** The nut member 13 may be fixed to the end plate 12 by brazing to prevent it from turning relative to the lifter body 11. As shown in Fig. 1, a slide member 22 is mounted between the adjuster screw 15 and the valve stem 2. The slide member 22 is kept from turning relative to the nut member 13 by a retaining mechanism 30 but so as to be axially movable.

**[0030]** As shown in Figs. 2 and 3, the retaining mechanism 30 has a ring-shaped turn-preventive member 31 provided under the nut member 13. The turn-preventive

member 31 is fixed to the nut member 13 ~~e.g. by~~ by, for example, caulking. A pair of guide pieces 34 extend downwardly from opposed positions of the inner periphery of the turn-preventive member 31. The guide pieces 34 are each formed with a guide hole 35 extending inwardly beyond the inner periphery of the turn-preventive member 31. On the other hand, L-shaped turn-preventive pieces 22a are provided at opposed positions of the outer periphery of the slide member 22. The turn-preventive pieces 22a are inserted in the guide holes 35 to prevent the slide member 22 from turning while allowing its axial movement. The turn-preventive member 31 is formed by pressing a thin metal plate.

**[0031]** In the valve gear of this structure, when the cam 1 is turned to push down the lash adjuster A with the protrusion of the cam 1, the valve stem 2 is pushed down by the adjuster screw 15, so that the valve 5 descends to open the intake port. When the base circle of the cam 1 opposes the end plate 12 of the lifter body 11, the elastic force of the valve spring 4 will raise the valve 5 and the lash adjuster A, thus closing the intake port.

**[0032]** During opening and closing of the valve 5, the distance between the base circle of the cam 1 and the top end of the valve stem 2 can change due to thermal expansion of the cylinder head B resulting from temperature change. If the distance increases, the

adjuster screw will move downward while rotating under the elastic force of the return spring 16 to absorb the change in the distance.

**[0033]** On the other hand, if the cylinder head B shrinks due to cooling as a result of stoppage of the engine, the distance between the valve stem 2 and the base circle shortens. Immediately after restart from the cold state, a clearance between the cam base circle and the valve stem end is ensured by the axial play of the threads, and the push-in force gradually acts on the adjuster screw 15, so that the adjuster screw 15 moves upward while rotating to absorb the change in the distance.

**[0034]** Thus, even if the distance between the base circle of the cam 1 and the top end of the valve stem 2 changes, since the adjuster screw 15 moves axially and absorbs the change in the distance, no abnormal clearance will be formed between the cam 1 and the end plate 12 of the lifter body 11 and between the opposed portions of the valve stem 2 and the adjuster screw 15. ~~Thus~~ Thus, the valve 5 can be opened and closed with high accuracy.

**[0035]** If a shift occurs in the distance between the cam 1 and the valve stem 2 from the optimum distance due to manufacturing or assembling errors, the adjuster screw 15 will move axially while rotating to absorb such a shift. This prevents any abnormal clearance from being formed between the cam 1 and the end plate 12 of the lifter body 11

and between the adjuster screw 15 and the valve stem 2.

**[0036]** The structure and function of the valve gear and the lash adjuster have been described. In this embodiment, as described above, a lash adjuster is used which can maintain the function as a valve gear even if FM oil is used for the automotive engine. This is because a material that will not react with oil additives containing organic molybdenum is used as the ~~materials~~ material of the nut member 13 and the adjuster screw 15, or the ~~materials~~ material of the pressure side thread surfaces that threadedly engage each other. Also, this suppresses the formation of tribochemical reactive film between the thread surfaces.

**[0037]** As such a non-reactive material, a chemically stable ceramic film may be formed from DLC, TiN, TiAlN, CrN, or TiCN on the pressure side thread surfaces of one or both of the nut member 13 and the adjuster screw 15. Also, besides ceramic film, plating such as hard chrome plating or electroless plating may be applied, or stainless, which is high in surface chemical stability, may be used as the material. Further, a nitride layer produced by nitriding treatment such as TUFFTRIDE® (salt bath soft nitriding) or sulfurizing, or an oxide film or carbon film are also chemically stable and ~~has~~ have a non-metallic property and can be used. Otherwise, as the material for the threads of one or both of the nut member13 and the adjuster screw 15,

a nonferrous metal such as titanium or aluminum may be used. By using such a material, it is possible to suppress the formation of tribochemical reactive film.

**[0038]** As specific examples of such plating treatment and carbon or ceramic film, the following can be cited. ~~That is, as~~ As the carbon film, a diamond-like carbon film may be used, and as the ceramic film, titanium nitride TiN or chrome nitride CrN may be used. As the plating treatment, the Ni-P plating, or Ni-P plating and treatment in which a hard particle-dispersed film such as SiC or $Si_3N_4$ is formed, or Ni-P plating and treatment in which PTFE-dispersed film is ~~formed~~ formed, may be used.

**[0039]** Fig. 4 shows measurement results in a sweep test for the number of revolutions of the lash adjuster of the above embodiment. The illustrated example is for a case in which a nitride layer of titanium nitride (TiN) is formed on pressure side thread surfaces of both the nut member and the adjuster screw. In the graph, the bent line A1 at the lower portion of the graph shows the number of revolutions of a crankshaft, which linearly accelerates from 800 rpm in idling to ~~max~~ a maximum of 6000 ~~rpm~~ rpm, and again linearly decelerates to 800 rpm.

**[0040]** The upper portion of the graph shows a lift curve B1 of the valve 5. While in the graph, only one lift curve is shown enlarged, actually, such lift curves appear continuously in the direction of the horizontal axis (time

axis) of the graph such that in a region where the number of revolutions of the crankshaft is low, the density of lift curves is coarse, and as the number of revolutions increases, the density of lift curves increases. Since it is difficult to accurately draw such lift curves, they are shown by connecting a valve closed position and a valve open position of a continuous lift curve. The upper line A ~~shows~~ indicates the valve closed position and the lower line B ~~shows~~ indicates the valve open position.

[0041] As will be apparent from the illustrated measurement results, it will be understood that even under conditions in which FM oil is used, if a lash adjuster subjected to TiN film treatment is used, the bottom ends of the valve lift curves are substantially linear. This shows that the valve lift amount is very stable. As a comparative example, measurement results for a conventional lash adjuster using an adjuster screw and a nut member made from carburizing steel subjected to carburizing are shown in Fig. 7. Under conditions in which FM oil is used, the bottom ends of the valve lift curves fluctuate about 0.2-0.3 mm and are not stable.

[0042] Figs. 5 and 6 show measurement results for a case in which DLC film treatment is applied to the adjuster screw only, and a case in which electroless nickel plating is applied to the nut member only, respectively. It is apparent that the valve lift amount is very stable in either case. ~~It is~~

~~needless~~ Needless to ~~say that~~ say, FM oil is used in ~~either case~~ both cases.

**[0043]** In the above embodiment, as an example, description has been made of a valve gear employing the lash adjuster A shown in Fig. 1. But there are various shapes and types of the lash adjuster. The invention is applicable to any of them as long as the adjuster screw and the nut member are similar to those of the above embodiment.

**[0044]** As described above, in the lash adjuster of this invention, since one or both of the adjuster screw and the nut member, or the pressure side thread surfaces of one or both of ~~them~~ them, are formed of a material that will not react with oil additives containing organic molybdenum (FM oil), even if FM oil is used for the engine, it will not lose its function as the lash adjuster in a valve gear, and a stable valve lift is maintained.

## ABSTRACT OF THE DISCLOSURE

In a lash adjuster of a valve gear which employs a serration-shaped thread mechanism, the formation of a tribochemical reactive film is suppressed by using as the materials for its adjuster screw and nut member ~~or~~ (or the materials for their thread ~~surfaces such~~ surfaces) materials ~~that~~ that, even if FM oil is used, the friction coefficient will not extremely ~~fall~~ decrease. The nut member is provided on the underside of an end plate of a lifter body. The adjuster screw is threadedly engaged in a threaded hole of the nut member. The adjuster screw is biased by a return spring. The female threads of the threaded hole and the male threads of the adjuster screw are serration shaped. One or both of the nut member and the adjuster screw, or the pressured thread surfaces of one or both of ~~them~~ them, are formed of a material that will not react with oil additives of FM oil to suppress the formation of tribochemical reactive film, thereby stabilizing the operation of the lash adjuster.